Design Concepts for a New Guarded Hot Plate Apparatus for Use Over an Extended Temperature Range with Controlled Gas Pressure or in Vacuum

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Outline

- Background
- Design specifications
- Thermometry
- Thermal components
  - Hot plate
  - Cold plate
  - Edge guard
- Pressure control system
- Mechanical systems
  - Support structure
  - Force application
  - Thickness measurement

Background

- History
- Rationale
- Design Concerns

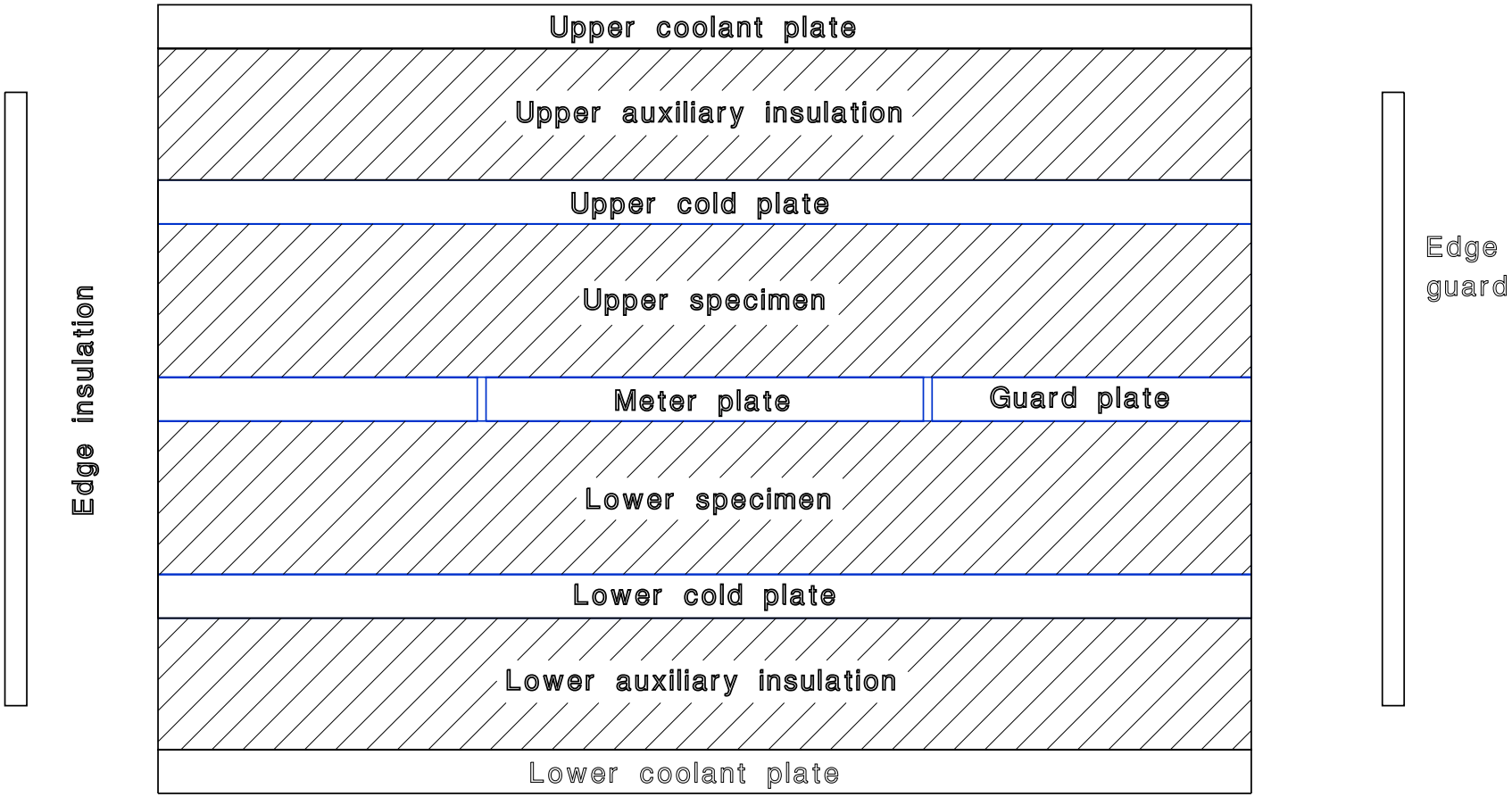
(These items are addressed
in the printed paper)

Current Standards and Apparatus

- ASTM C 177 and ISO 8302 are good at atmospheric pressure from, say, 230 K to 330 K
- Interlaboratory comparisons from 400 K to 1000 K show $\pm$ 12 % to $\pm$ 18 % differences
- Cryogenic temperatures: No comparisons
- Vacuum conditions: No comparisons

Conclusion: ASTM C177 and ISO 8302 are inadequate at very high or low temperatures and in vacuum

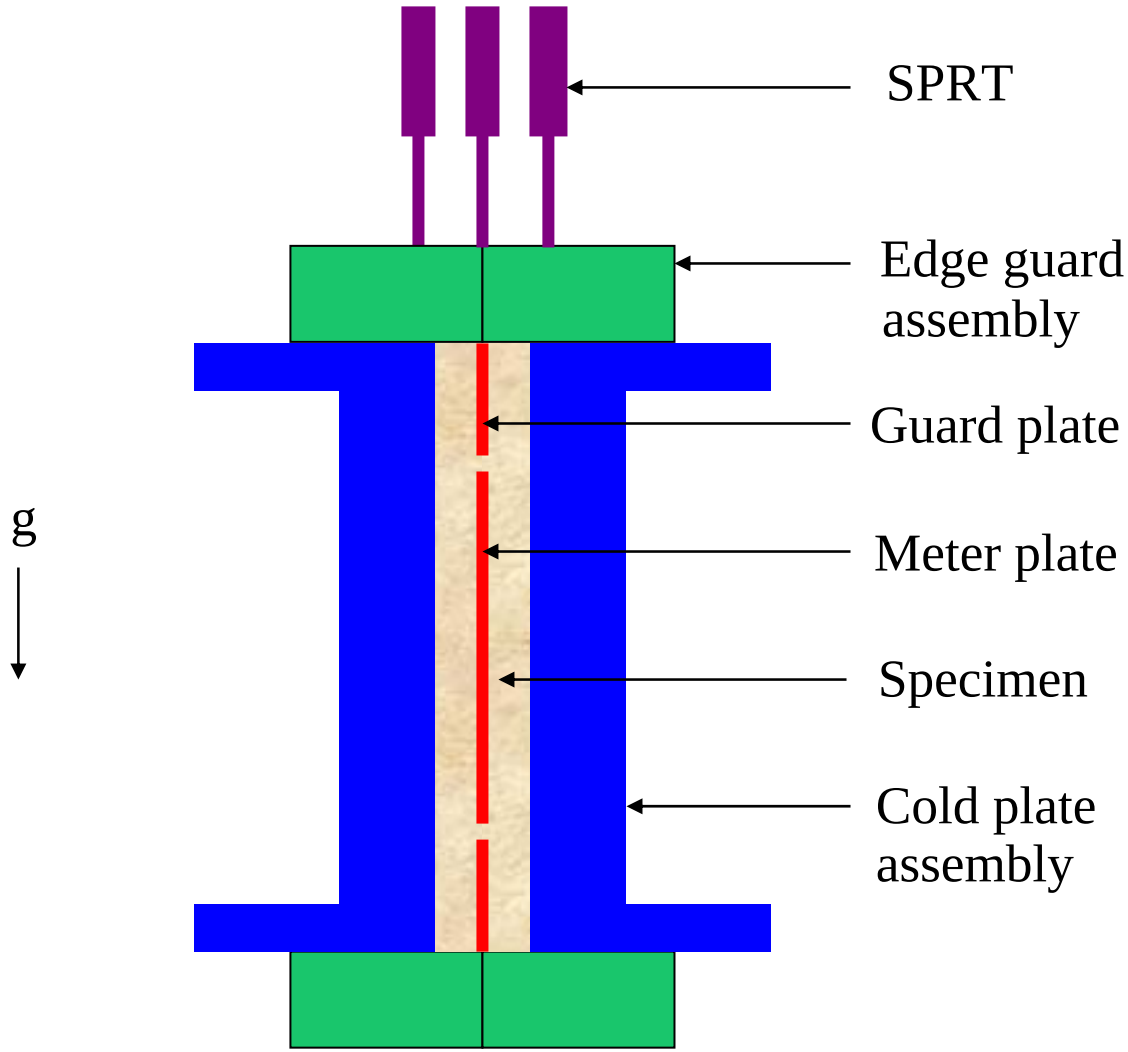
Typical High-Temperature Guarded Hot Plate Apparatus



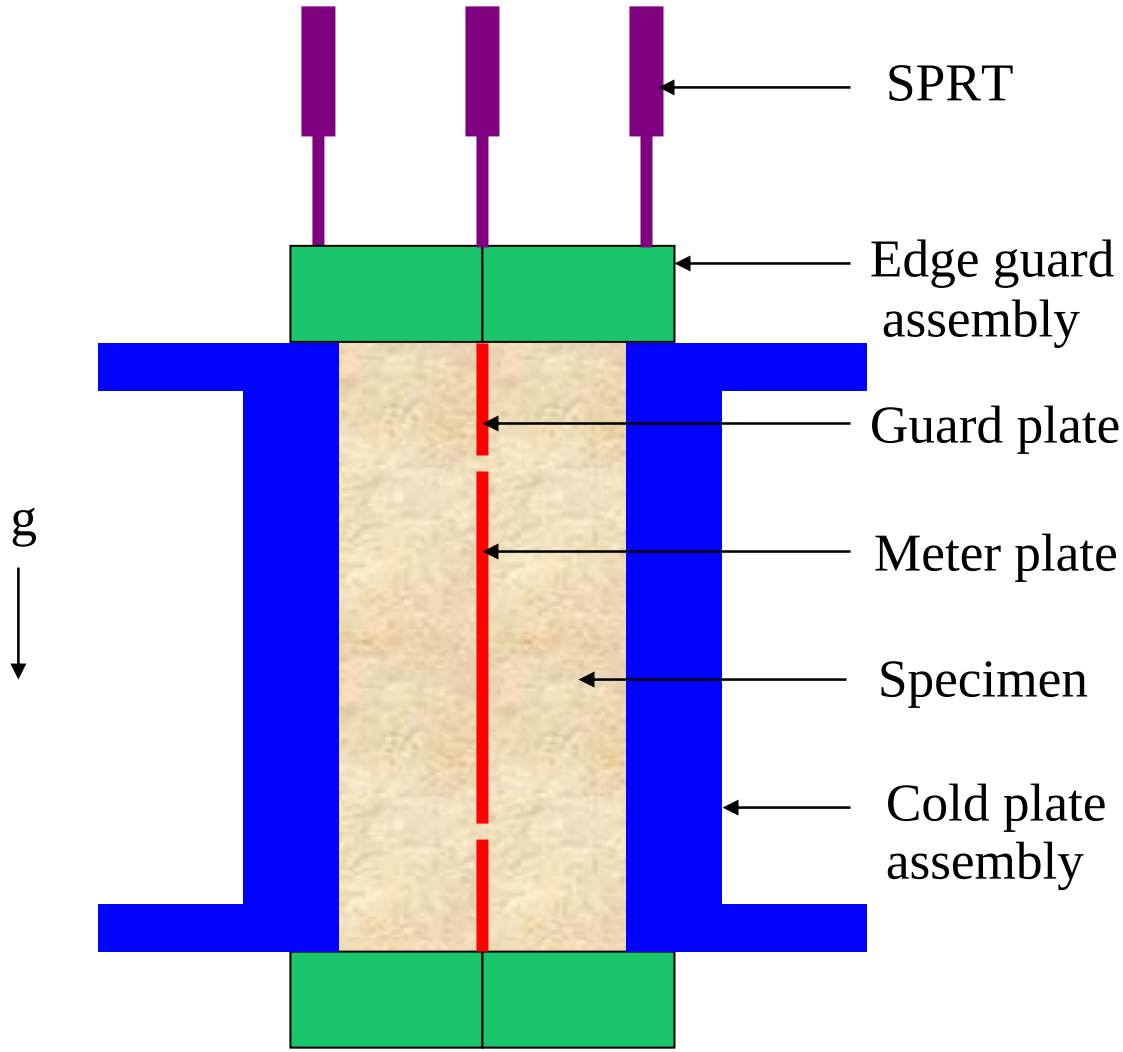
Design Specifications

- Specimen diameter: 500 mm
- Meter plate diameter: 200 mm
- Specimen thickness: 10 to 110 mm
- Range of mean temperatures: 90 K to 900 K
- Gas pressure: 10^{-4} torr to 790 torr
- Horizontal heat flow
- Desired uncertainty at 300 K: 1 %
- Desired uncertainty at 90 K and 900 K: 2 %

Overall Layout of Thermal Components



Layout with Thick Specimens

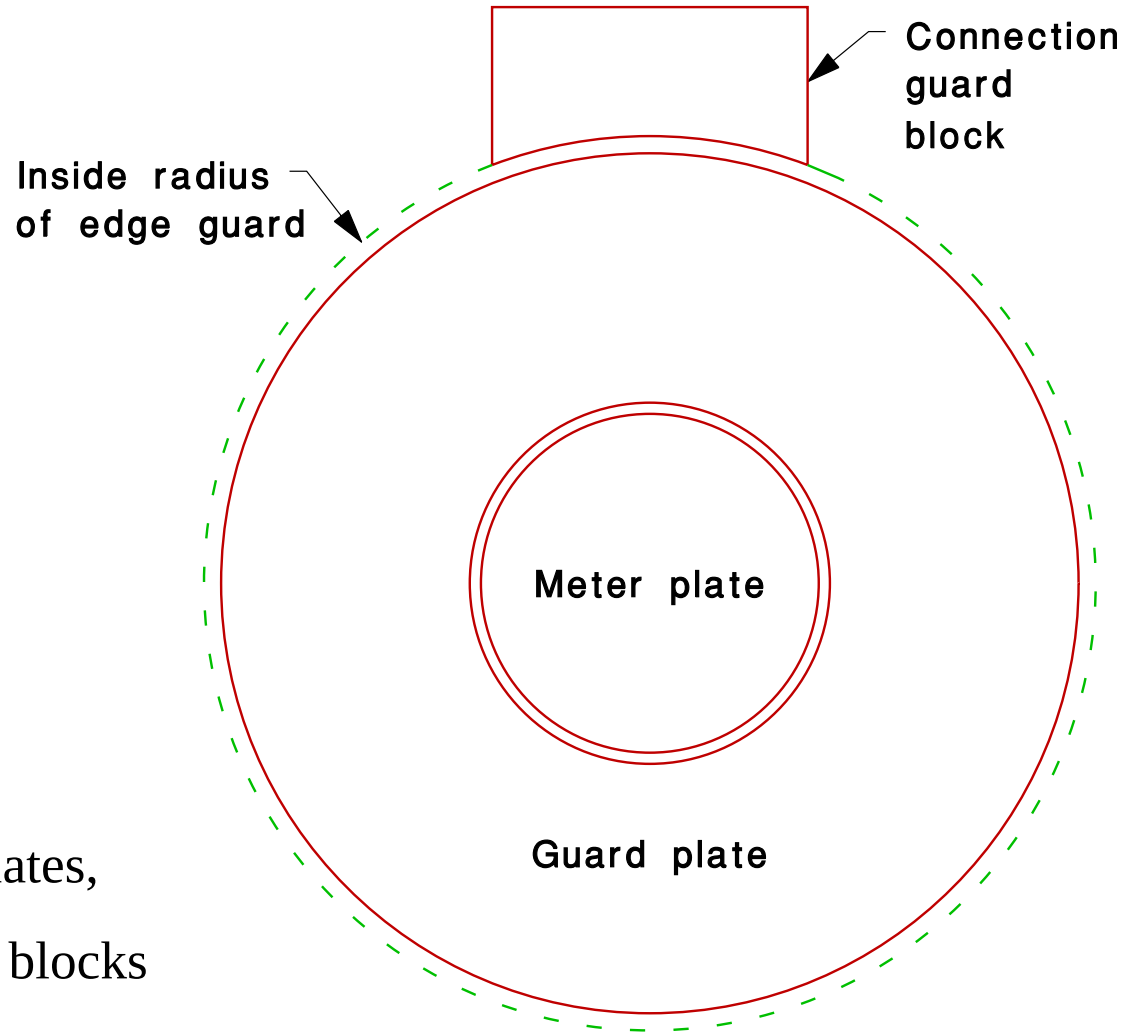


Thermometry

- Hot & cold plates:
  - Measurement: Pt resistance thermometers (±1 mK) plus Type N thermocouples (±0.6 K)
  - Control: Nickel heaters as resistance thermometers
- Edge & connection guards:
  - Type N thermocouples (±0.6 K)
- Gap thermopiles:
  - KP vs. 65% Au-35% Pd

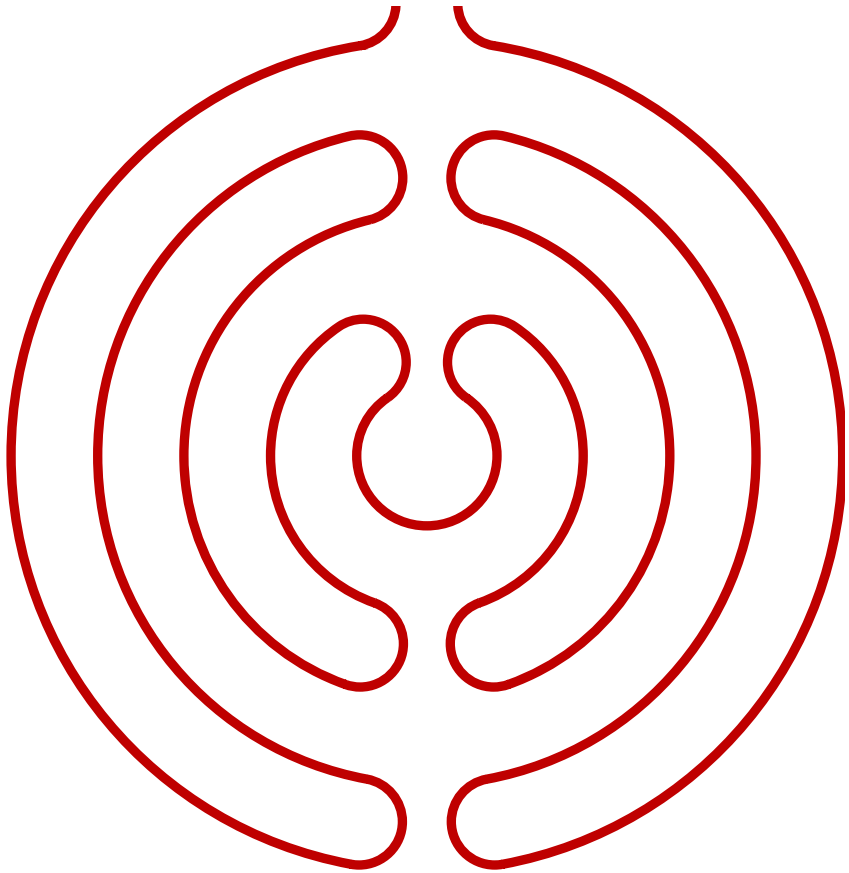
(Note: thermocouples & piles are sheathed units with compacted ceramic insulation)

Overall Layout of Hot Plate

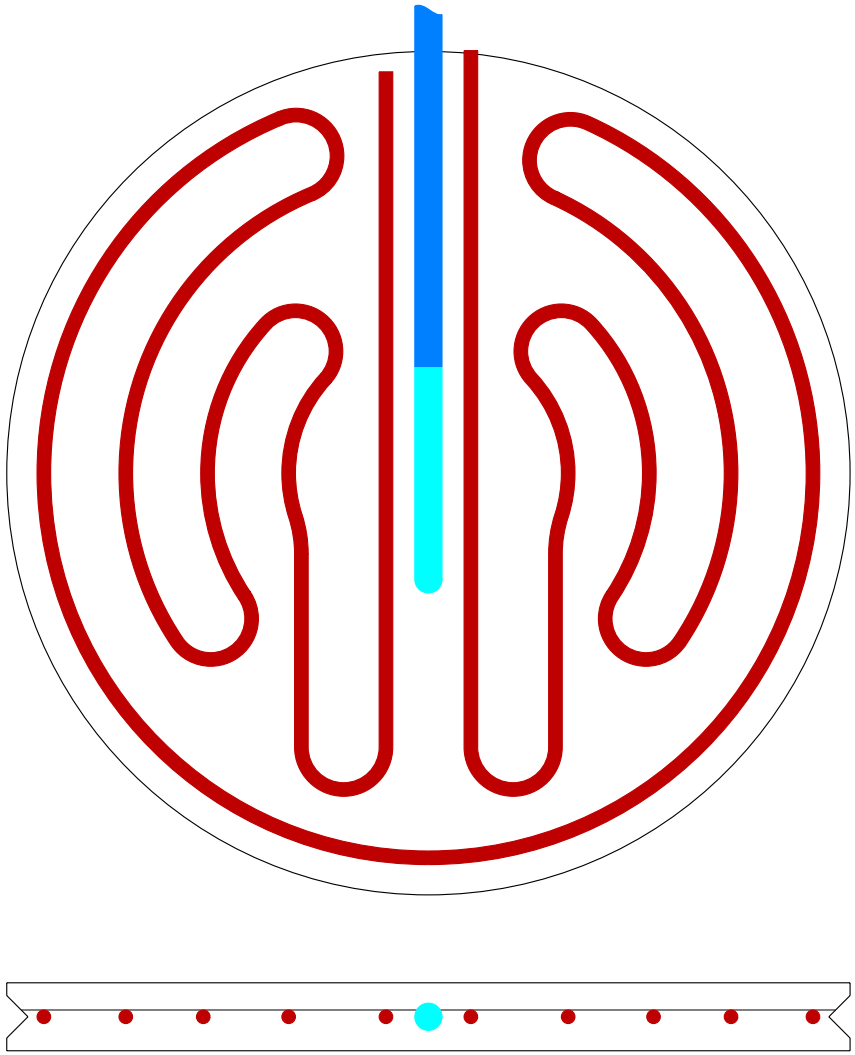


Note: all plates, guards, and blocks are made of nickel

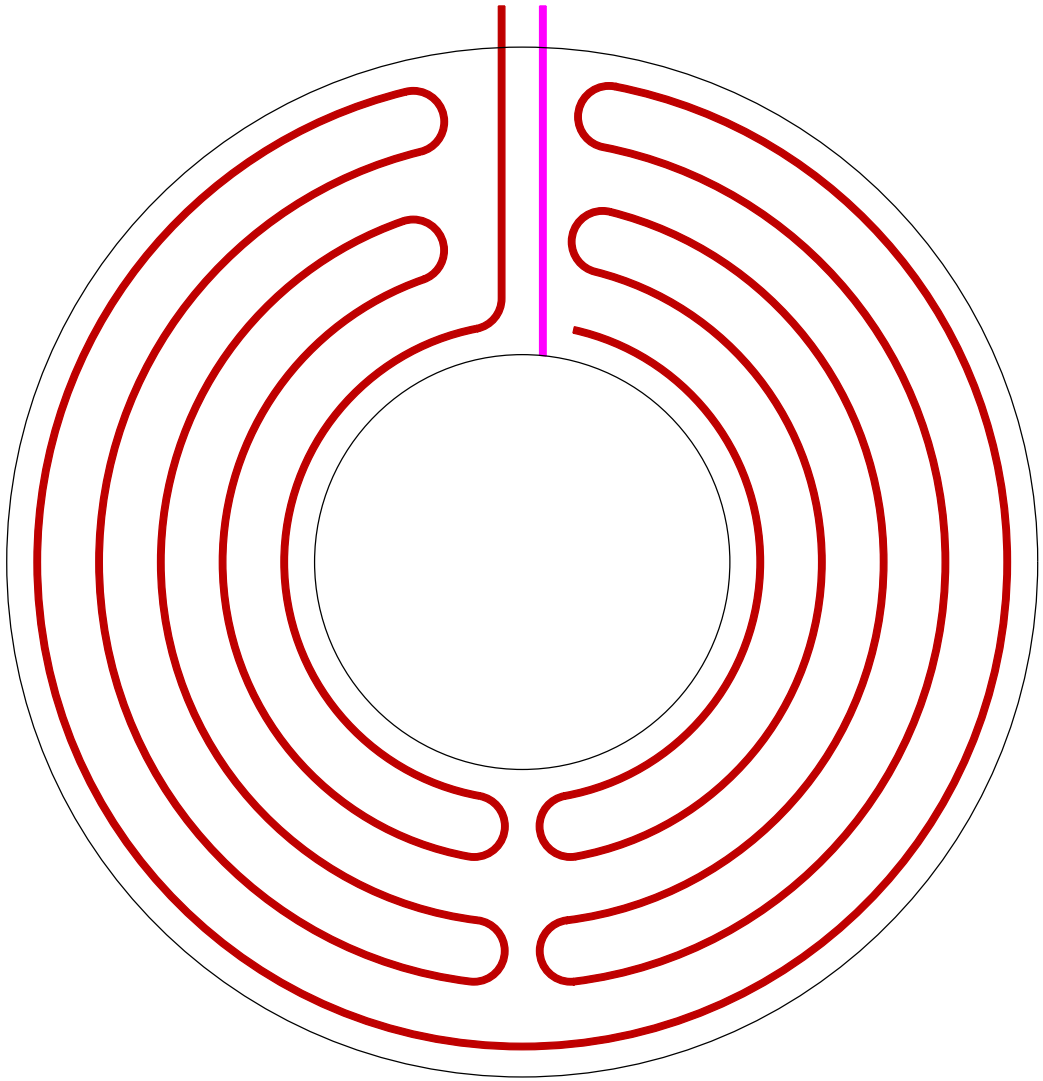
Meter Plate Heater for Use with Thermocouples



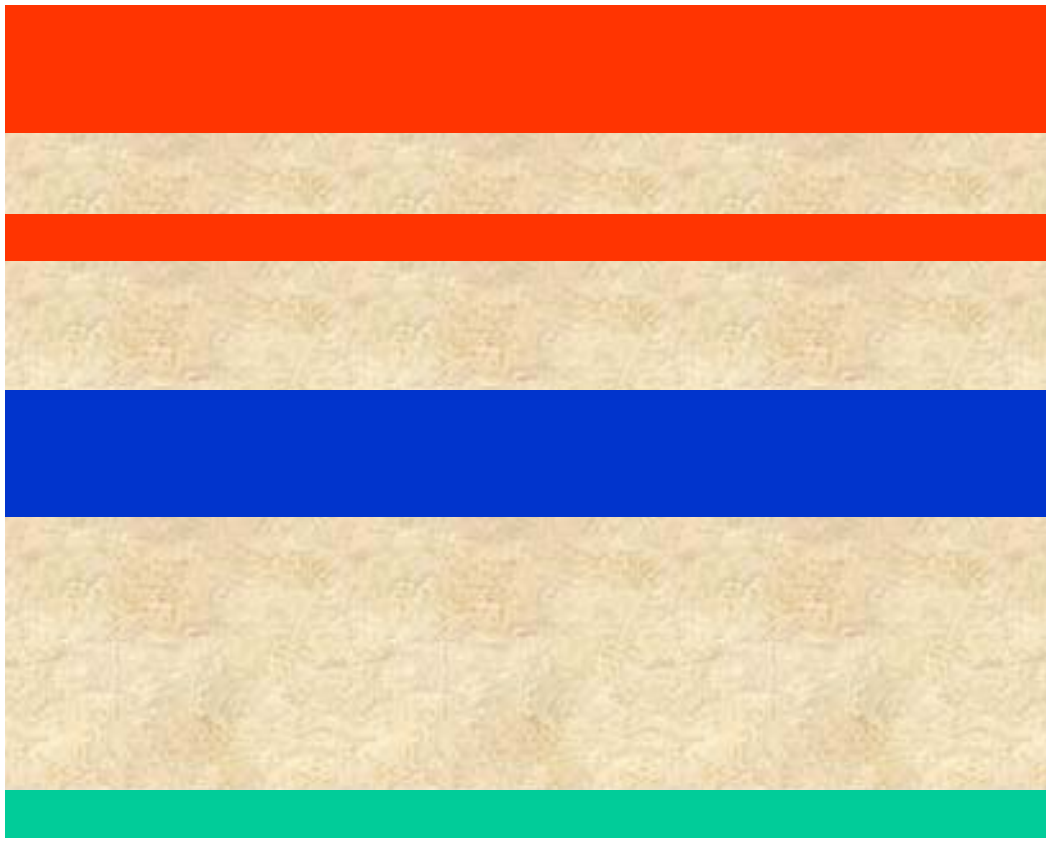
Meter Plate Heater for Use with SPRTs



Guard Plate Heater



Cold Plate Assembly



Thermometry plate

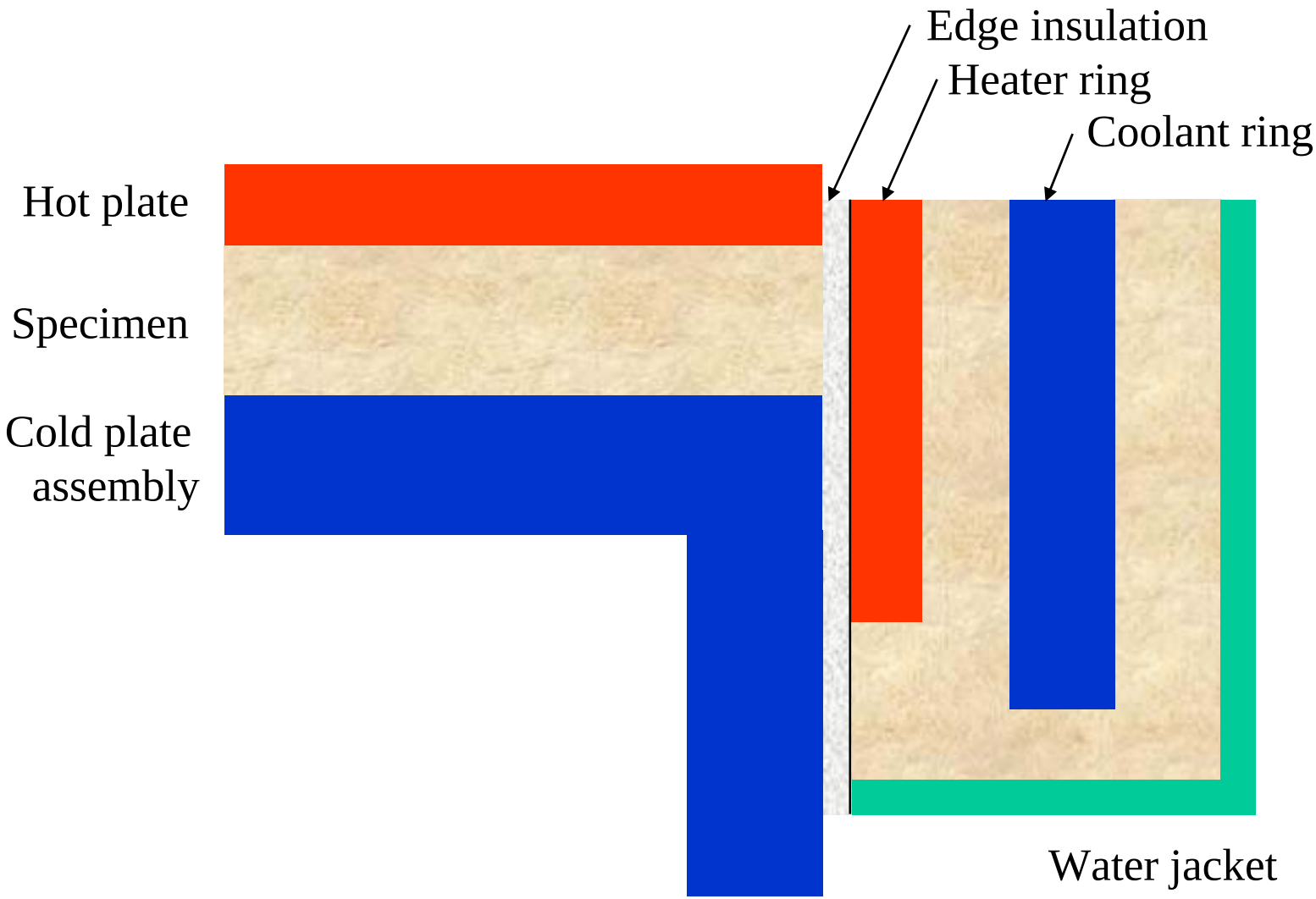
Heater plate

Coolant plate

Water jacket


MAKINO
A55

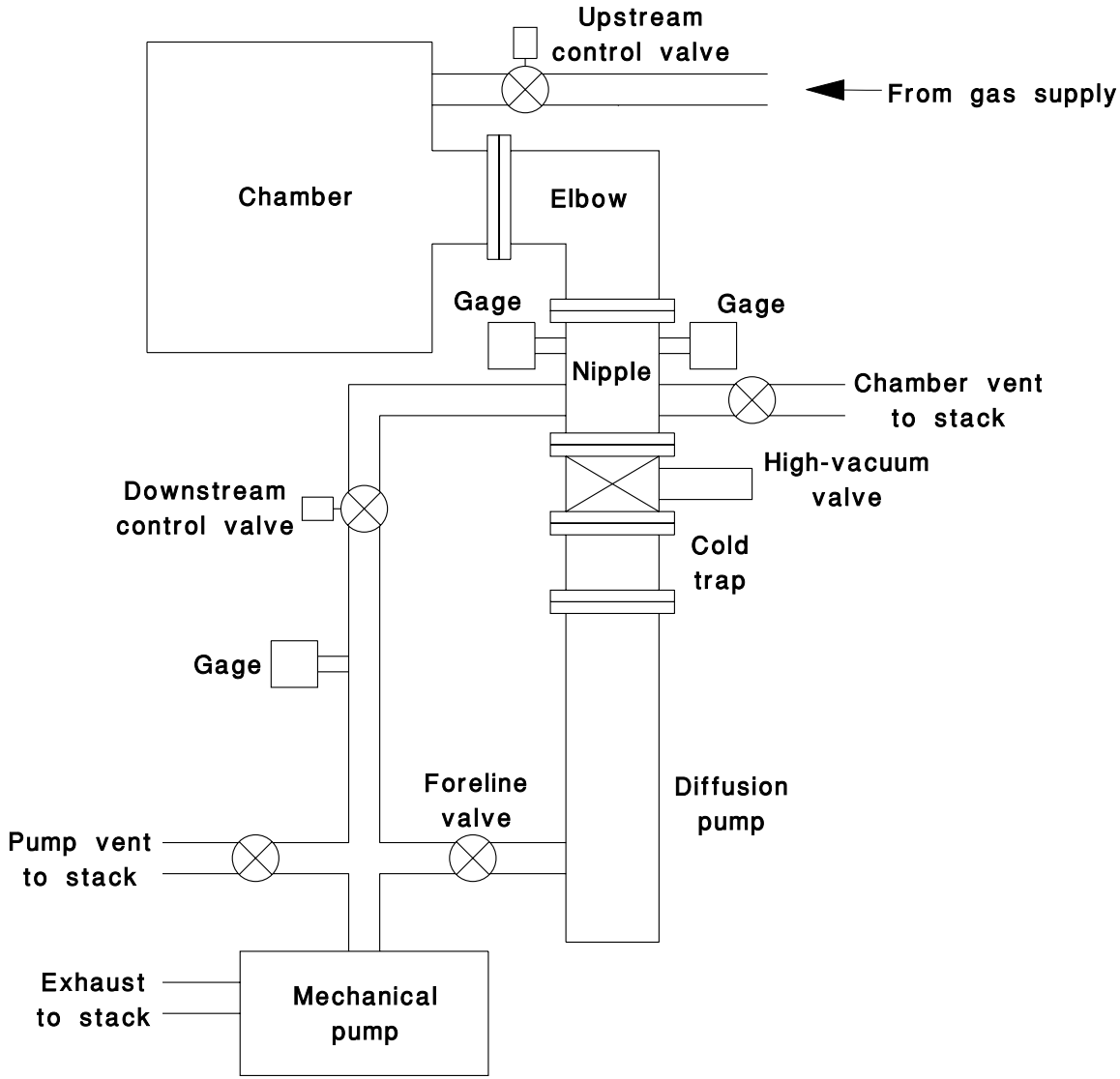
Edge Guard Assembly

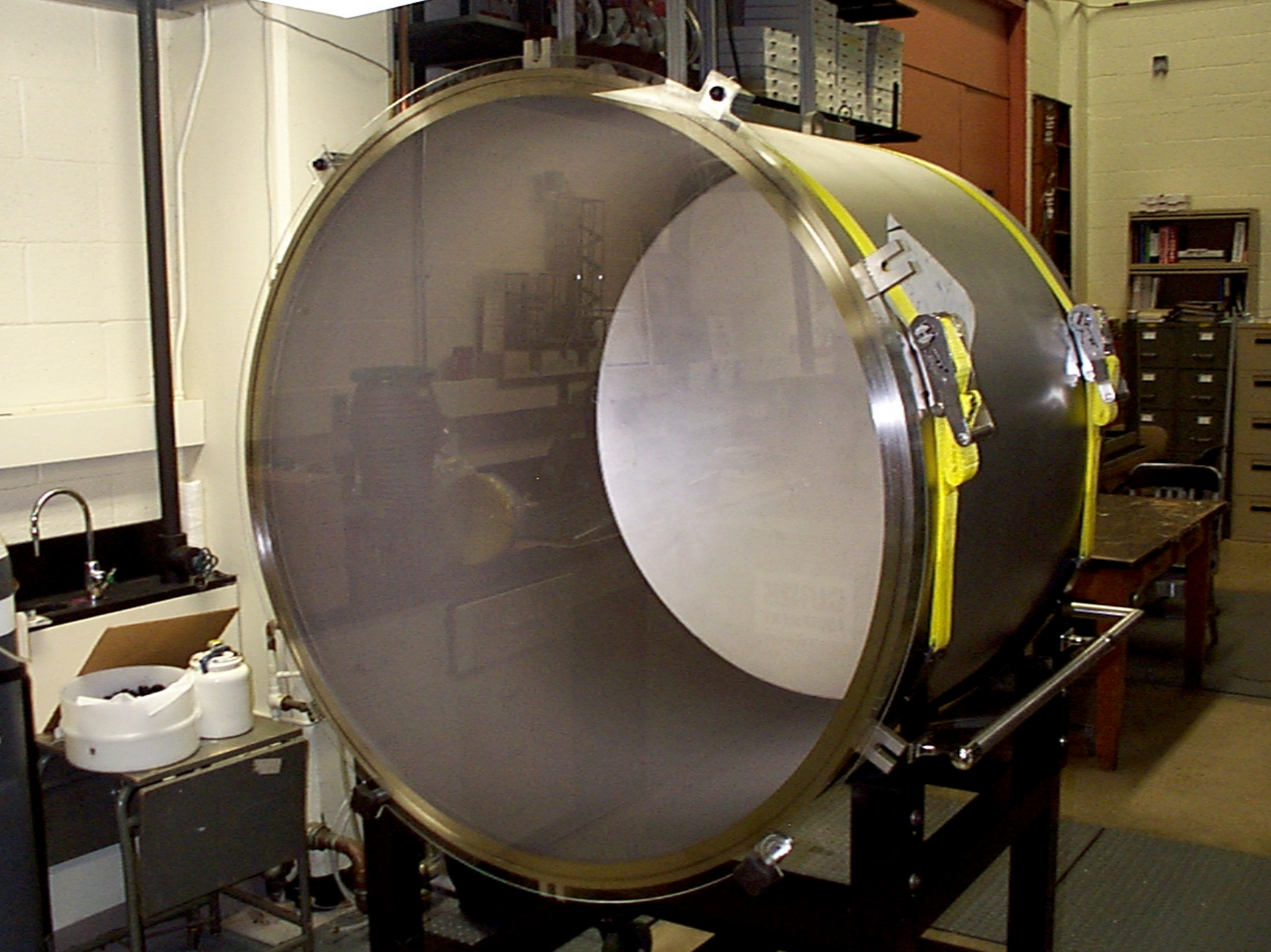


Pressure Control System

- 1.2 meter diam. bell jar
- Vertical baseplate
- Mechanical vacuum pump (MP)
- Oil diffusion pump (DP) when necessary
- Capacitance pressure gages
- Upstream gas flow adjustable
- Active downstream pressure control
  - MP plus on/off control
  - MP plus butterfly valve with PID control
  - DP plus pendulum valve with PID control

Layout of Pressure Control System

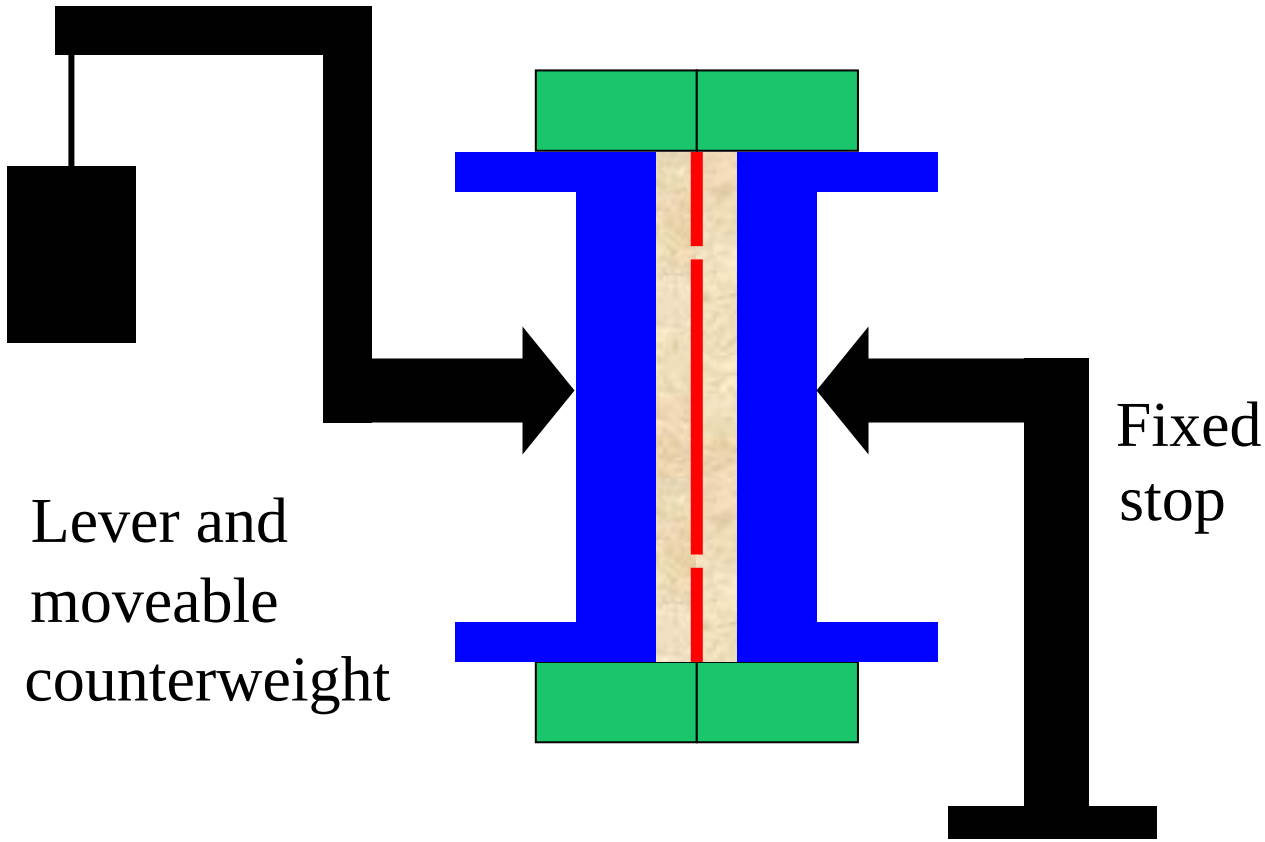




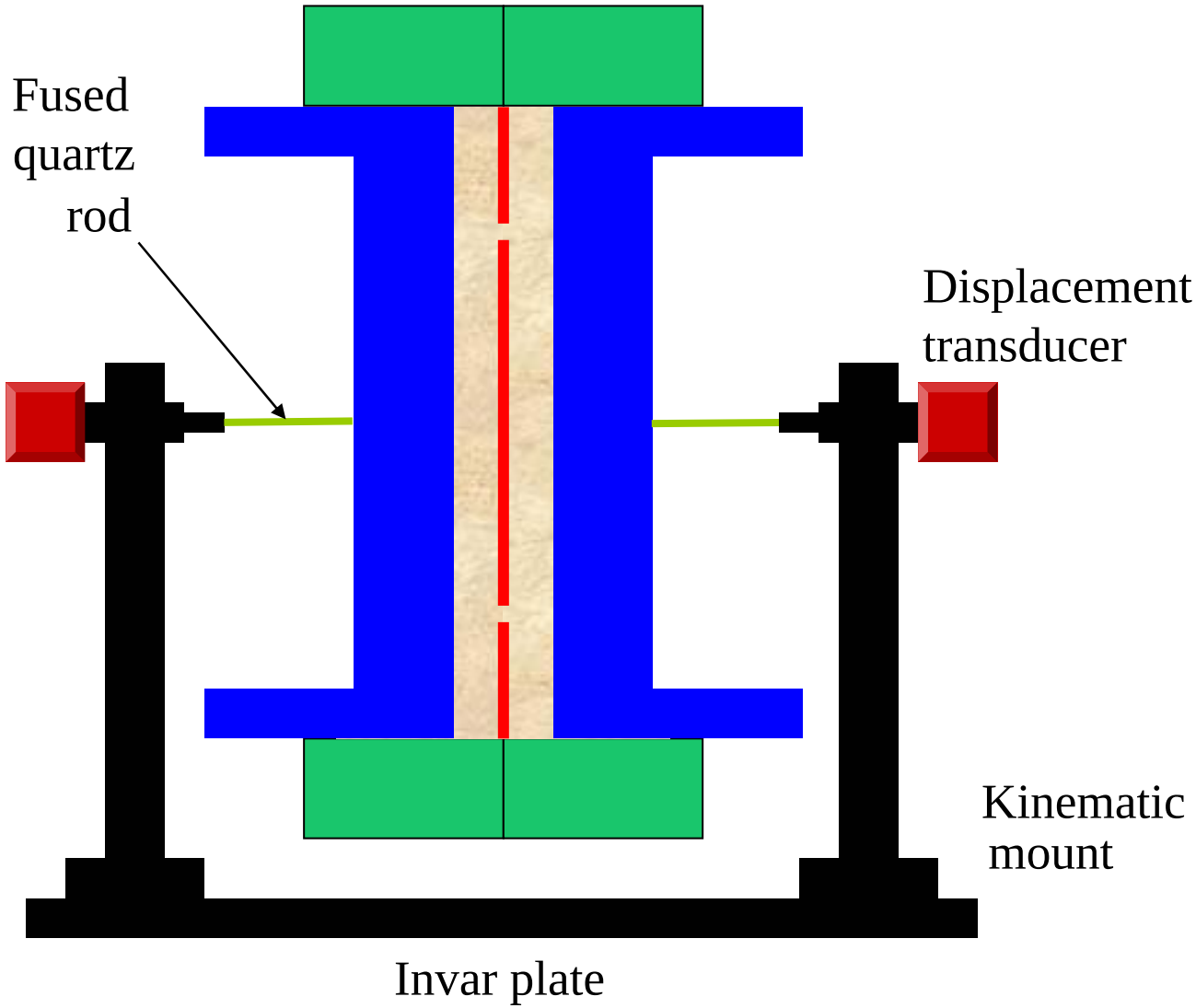
Mechanical Systems

- Support structure
- Force application
- Thickness measurement

Force Application System



Thickness Measurement System

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Summary

- Solid metal GHP with embedded heaters
- Integrated cold plate assemblies
- Long-stem SPRTs in plates
- Integrated edge guard assemblies
- Connection guards to control parasitic heat flow
- Controlled application of force to cold plates
- *In situ* thickness measurements
- Vacuum enclosure and pressure control system
- Operate from 90 to 900 K w/o opening system